

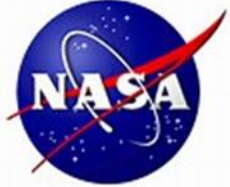
Commercial Crew Medical Ops



Purpose:

Provide Commercial Partners with:

- Insight into NASA spaceflight medical experience
- Information relative to both nominal and emergency care of the astronaut crew at landing site
- A basis for developing and sharing expertise in space medical factors associated with returning crew
- *NOTE: The information provided herein does not imply, create or direct any new CCT-REQ-1130 requirements. Commercial Providers have requested NASA Medical Operations to provide expanded commentary on selective requirement items. Any requirement changes or official interpretation is the purview of the Commercial Crew Program Office.*



Spaceflight & The Human



- General effects observed in the human
 - Physiologic adaptation to microgravity
 - Maladaptive responses in the post-flight period
- Physiologic Issues
 - 50 years of spaceflight history
 - Space Adaptation Syndrome and Entry Adaptation Syndrome
 - Fluid shifting
 - Cardiovascular deconditioning
 - Neurosensory/neurovestibular disturbance
 - Musculoskeletal atrophy
- Other post-landing medical considerations in Long Duration Flight (LDF >30-180 days) are being observed



Microgravity Adaptation



Relative to terrestrial normal, the returning deconditioned, microgravity-adapted crew has:

- Hypovolemia –12% to 15% less blood volume (like dehydration)
- Anemia –10% to 12% less red blood cells
- Neurosensory deconditioning
- Aerobic deconditioning –15% to 20% deficit
- Decreased strength (postural muscles)
- Decreased bone density (postural joints)
- Increased spinal length (about 6%; may affect suit fit)

Bottomline: This list may support normal function in microgravity, but become absolute deficits in **the post-flight period**.



Space Adaptation Syndrome



- Space Adaptation Syndrome(SAS)
 - Typically experienced in microgravity during first 2-3 days of spaceflight.
 - Nausea, Vomiting, Visual Illusions, Spatial Disorientation, Pallor, Fatigue, Malaise, Cold Sweat
 - Experienced by significant % of crews
- Entry Adaptation Syndrome (EAS)
 - Response to transitioning from microgravity back to 1G
 - Inverse of SAS
 - Similar symptomology and manifestations contribute to dehydration and orthostatic intolerance
 - Experienced by similar percentage of returning crews



Maladaptive Response to Terrestrial Return (1G)



- Orthostatic intolerance (hypovolemia, anemia, neurologic ability to sense gravity challenge)
- Entry Adaptation Syndrome (inverse of space adaptation syndrome)
- Postural instability and motion disturbances (neurosensory deconditioning)
- Impaired fitness (generalized muscular weakness, diminished aerobic capacity)
- Decreased bone density (possible increased fracture risk)
- Fatigue (sudden substantially increased effort required to move)
- Circadian Rhythm Disorder, shift work type (sleep shifting to match undocking and landing in a new time zone)

*** Landing loads and environmental factors may add to these*



Injuries and Conditions Seen at Soyuz Landing



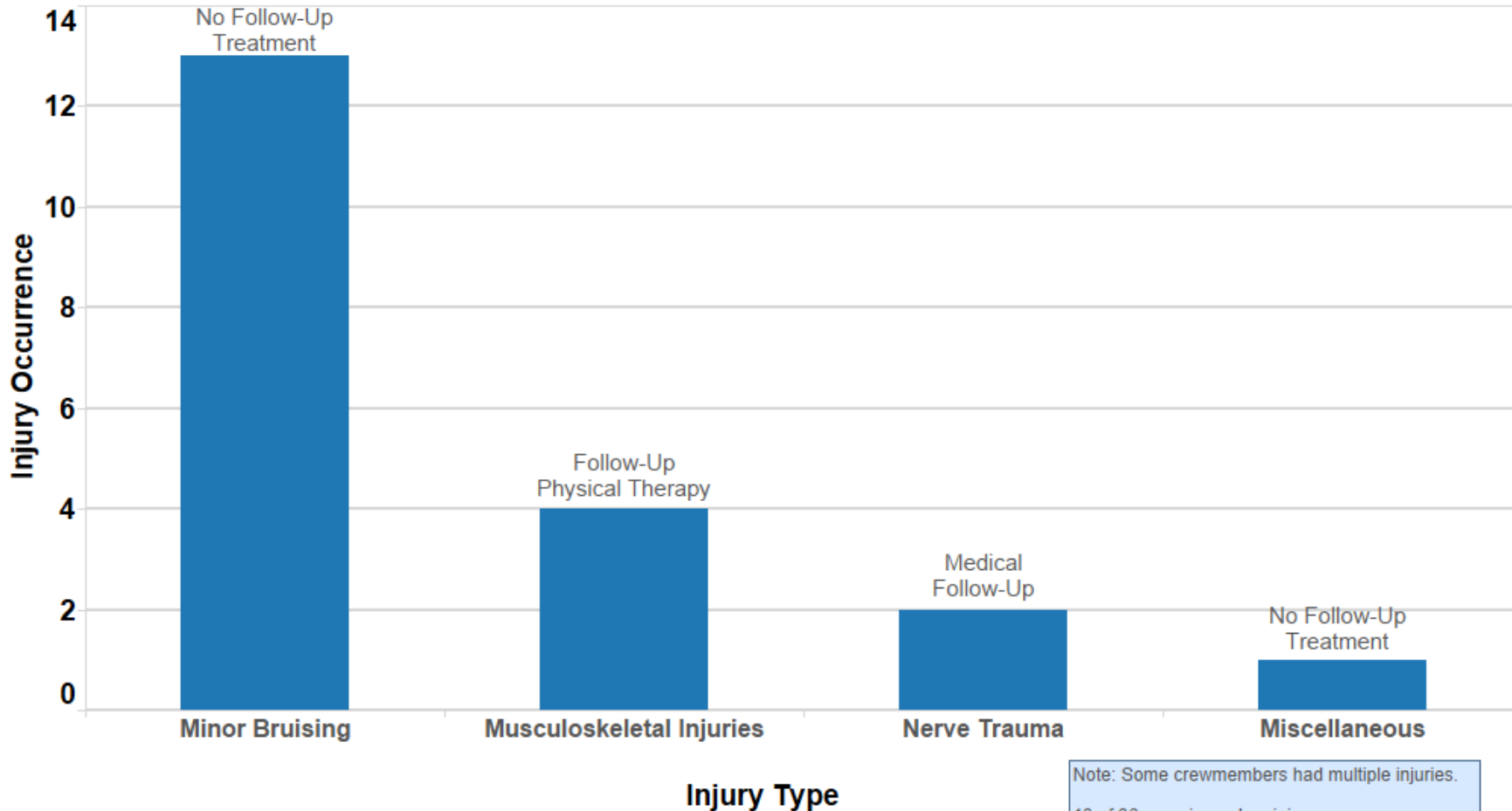
- Retinal ischemia (one)
- Contusions, abrasions, soreness (multiple)
 - Knee from impact with console
 - Scapula from impact with seat
 - Body areas associated with seams and folds of suit
 - Landing impact vs suit donning/doffing
- Costochondritis (inflammation) of chest wall from suit trauma on vehicle extraction (one)
- Mild reduction of sensation along radial nerve distribution (one)



Injuries and Conditions Seen at Soyuz Landing



Injuries due to Soyuz Landings - Expeditions 6-42
US Crew Only - 36 Individuals

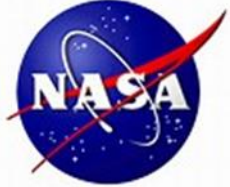




Other Post-landing Medical Considerations



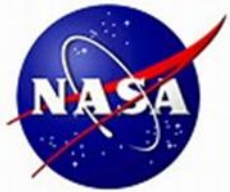
- Pharmacology
 - Dosing and sensitivity (altered fluid status, altered gene expression)
 - Individual variability
 - Synergistic medication reactions
 - Prophylactic antiemetic medications taken by crew before undocking
 - Hypothetical elevated extrajunctional receptors
 - Anesthesia summit cautioned use of succinylcholine, morphine, ketamine
- Urinary Retention
 - Increased incidence seen in spaceflight
 - May be observed in immediate post-flight period
 - Known side effect of medications given for Entry Adaptation Syndrome
 - Can be exacerbated with fluid loading protocols
 - Commonly requires intervention (catheterization)
 - Important to monitor crew fluid intake and output
- Herniated Nucleus Pulposus
 - Spaceflight hypothetically thought to increase risk by spinal elongation
 - Has not been seen in the immediate post flight period, but increased potential to occur
 - Increased incidence seen in the first year following spaceflight



Post-Landing Medical CONOPs



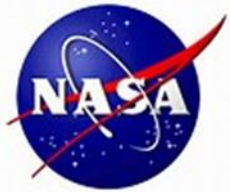
- Immediate post-flight period at the landing site
- Commercial Partner provides:
 - All emergency medical equipment and care
 - MEDEVAC and Other Transportation
 - Dedicated private Medical Evaluation Area
- NASA Flight Surgeon provides:
 - Care for nominal crew events
 - Post-flight Medical Evaluation
 - Treatment for typical re-adaptation issues –
 - orthostatic intolerance/fluid imbalance/volume depletion
 - nausea
 - cardiovascular and muscular deconditioning
 - neurovestibular impairment
- Either NASA or Commercial Partner may call up the medical evacuation system



NASA Crew Surgeon Landing Medical Kit



- Conduct the Post-flight Medical Evaluation
- Used by NASA flight surgeon to address these typical re-adaptation issues
 - Monitoring of basic vital signs (temp, pulse ox, bp)
 - Dehydration/volume depletion (fluid status)
 - Nausea/vomiting
 - Neurovestibular impairment
- May be delivered to landing site each mission or permanently pre-positioned and maintained by NASA at/near the landing site
- May have some overlap with consumables already provided and in place for emergency care by Commercial Provider medical team



NASA Crew Surgeon Landing Medical Kit



Following items are typically used by NASA flight surgeon for post-flight crew medical evaluations and re-adaptation issues

- BP cuff
- Pulse oximeter
- 12L Saline (3L per is minimum)
- IV set up (2 per crewmember)
- Array of intravenous catheters
- Bottled water/Drinking straws
- Hand towels
- Emesis bags
- Medications: Promethazine, Ondansetron, Diphenhydramine, Meclizine
- OTC analgesics
- Digital thermometer
- Headlamp
- Handheld ultrasound



Landing Site Emergency Medical Cart



- Provided on-scene by the Commercial Provider
- Basic and Advanced airway equipment including suction
- Intravenous access equipment
- ACLS medications to include treatment of atrial fibrillation
- Medications and equipment to treat known side effects of potential medications (ex. Diphenhydramine for dystonic reactions, epinephrine et al. for allergic reaction, urinary catheters for urinary retention, Naloxone for opioid overdose, etc.)
- Defibrillator and monitoring equipment (BP, Pulse Ox, end tidal CO2)
- Trauma equipment – chest tubes, water seal, hemostatic agent, tourniquets, etc.
- Burn supplies



Medical Evaluation Space



This space would typically include:

- 10'x 10' room/space for every two crewmembers. Rectangle seems better than a square. Most clinic/ER rooms are rectangle. Humans are longer than they are wide. All medical space is co-located together.
- Stretchers/tables/gurneys/recumbent chairs with IV pole attachment/hook for each crew. An electronic recumbent device that lays flat to be a gurney is acceptable.
- 3 foot aisle between the gurneys/tables in each room. Gurneys/tables with locking wheels can be moved around to accommodate patient work space.
- A privacy curtain (better than a hard wall) between and around them. Full envelope is best for curtain (maybe u-shaped).
- Small cabinet/nightstand or Mayo stand or equivalent for procedures
- Nearby water/sink. Quantity (TBD) of potable water and dispenser is required. Towels/Soap for hand washing
- Standard 110v power outlets within each curtained area is desired, but not required.
- Straight back chairs or rotating procedural stool in each room/area.
- Sharps container and biohazard bag
- Trash can
- Table for the CS landing medical kit.
- Restrooms nearby
- Adequate HVAC/climate control
- Adequate room lighting
- Blankets/sheets
- Refrigerator/ice chest for food and water



A Sample Medical Model



- The following slide presents one method of graphically presenting a reference model to assist in identifying medical conditions and proposed treatments and protocols.
 - Not intended to represent any Provider's specific design reference mission
 - Not intended to be an inclusive model of expected conditions identified by NASA for Commercial Crew Program missions
 - Not intended to represent a NASA-approved solution for Providers' emergency medical solution



Candidate Emergency Medical Conditions

Medical Conditions Model

Re-Adaptation Syndrome

Orthostatic Intolerance
- Anemia
- Volume contraction

Neurovestibular Impairment
- Nausea
- Emesis
- Motion disturbances

Generalized Weakness
- Cardiovascular deconditioning
- Muscular deconditioning

Spacecraft Failure

Airway

Closed-Open Head

Chest

Abdominal

Cardiac

Spinal

Eye

Fracture - Crush

Laceration

Burn

Hypoxia

DCS

Barotrauma

Environmental

Hypothermia

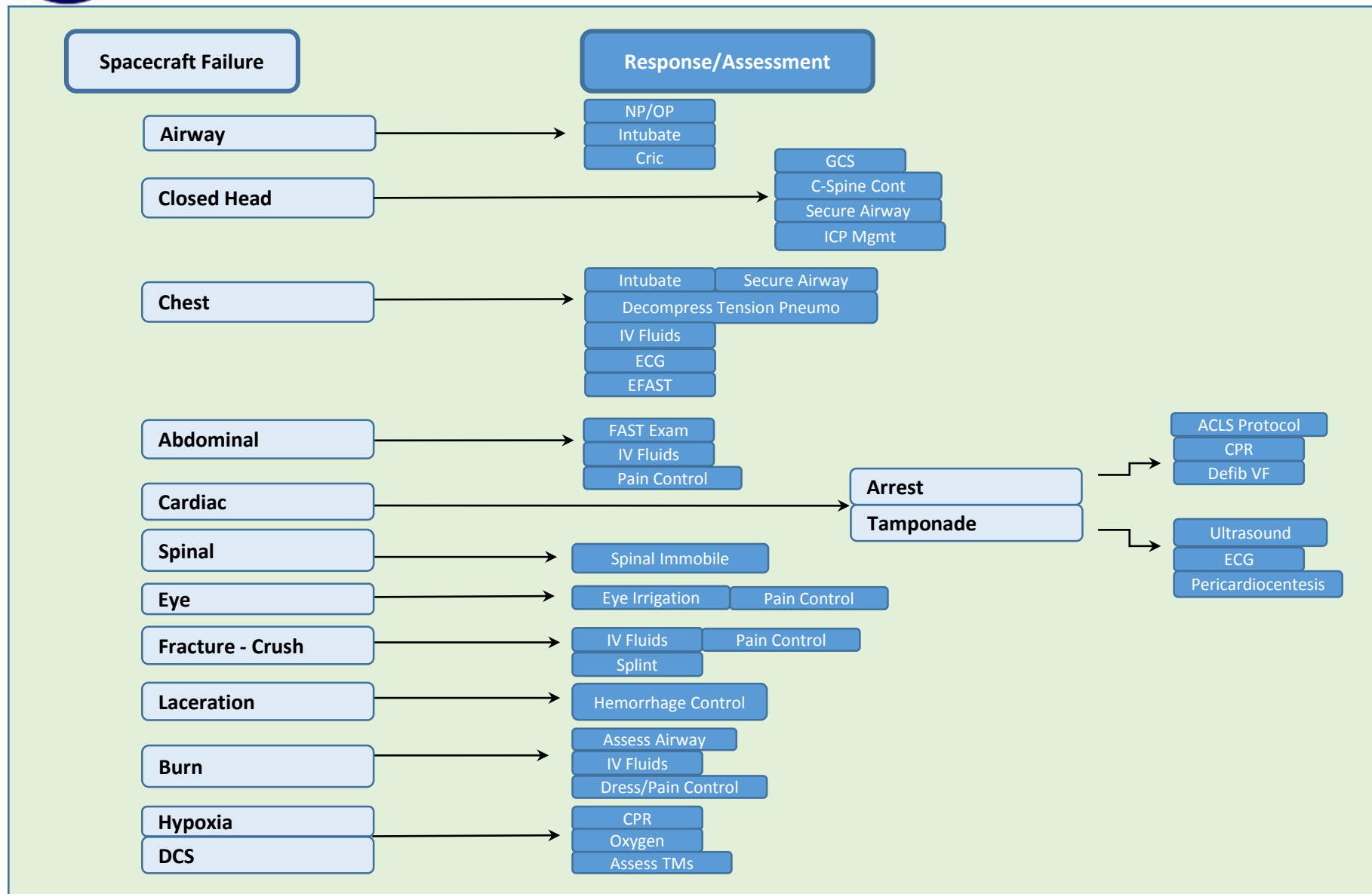
Hyperthermia

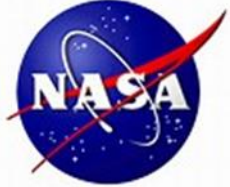
Drowning

Toxic Exposure



Sample Emergency Medical Conditions Model





Additional Reference



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